Serial No.: 09/875,063

IN THE SPECIFICATION:

Please replace paragraph **[0001]** with the following:

**[0001]** Field of the Invention: This invention relates generally to a method and apparatus for dicing or sawing semiconductor substrates having encapsulated semiconductor devices thereon and more specifically to a saw and chuck and method of using the same employing using multiple indexing techniques and multiple blades for more efficient sawing from an array of semiconductor devices on a substrate.

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Please replace paragraph **[0006]** with the following:

**[0006]** Once the individual or singulated semiconductor die have been sawed, the semiconductor die are further processed by being removed from the wafer tape, attached to substrates and packaged, such as the semiconductor die being adhesively attached to a substrate in a board-over-chip configuration (BOC), connections made between the semiconductor die and the circuits of the substrate by wire bonding, and the semiconductor die and portions of the substrate being encapsulated. While the semiconductor die and substrate may be individually handled, it is more efficient to process a plurality of semiconductor die, each semiconductor die being individually mounted, on a substrate having a configuration providing for each individually mounted semiconductor die thereon and circuits for connection with each individually semiconductor die as well as for the encapsulation of each individual semiconductor die mounted on the substrate.

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Please replace paragraph **[0007]** with the following:

**[0007]** However, existing process equipment and apparatus do not have the capability of singulating the packaged semiconductor die on a substrate when a plurality of semiconductor die are contained in an array on a substrate.

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Please replace paragraph **[0008]** with the following:

**[0008]** Accordingly, an apparatus and method for sawing semiconductor substrates, including substrates having a plurality of semiconductor devices of different sizes and/or shapes therein, is provided. In particular, the present invention provides a saw and method of using the same capable of "multiple indexing" of a saw blade or blades to provide the desired cutting capabilities. As used herein, the term "multiple indexing" contemplates and encompasses both the lateral indexing of a saw blade at multiples of a fixed interval and at varying intervals which may not comprise exact multiples of one another. Thus, for conventional substrate and/or wafer configurations containing a number of equally sized integrated circuits, the wafer saw and method herein can substantially simultaneously saw the substrates and/or wafers with multiple blades and therefore cut more quickly than single blade wafer saws known in the art. Moreover, for wafers having a plurality of differently sized or shaped integrated circuits, the apparatus and method herein provides a multiple indexing capability to cut nonuniform dice from the same wafer.

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Please replace paragraph **[0028]** with the following:

**[0028]** As illustrated in drawing FIGS. 1 and 2, an exemplary wafer saw 10 to be used with the present invention is comprised of a base 12 to which extension arms 14 and 15 suspended by support 16 are attached. A substrate saw blade 18 is attached to a spindle or hub 20 which is rotatably attached to the extension arm 15. The blade 18 may be secured to the hub 20 and extension arm 15 by a threaded nut 21 or other means of attachment known in the art. The substrate saw 10 also includes a translatable substrate table 22 movably attached in both X and Y directions (as indicated by arrows in drawing FIGS. 1 and 2) to the base 12. The table 22 used to hold the chuck 500, 500′ (See drawing FIGS. 7, 8, 13, and 14) of the present invention thereon by any suitable attachment apparatus. Alternatively, blade 18 may be translatable relative to the table 22 to achieve the same relative X-Y movement of the blade 18 to the table 22. A substrate 24 to be scribed or sawed at 24′ may be securely mounted to the table 22. As used herein, the term "saw" includes scribing of a substrate, the resulting scribe line not completely

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extending through the substrate. Further, the term "substrate" includes any suitable type substrate to which a semiconductor device may be attached, such as FR-4 board, silicon substrate, traditional full semiconductor wafers of silicon, gallium arsenide, or indium phosphide and other semiconductor materials, partial wafers, and other equivalent structures known in the art wherein a semiconductor material table or substrate is present. For example, so-called silicon-on-insulator or "SOI" structures, wherein silicon is carried on a glass, ceramic or sapphire ("SOS") base, or other such structures as known in the art, are encompassed by the term "substrate" as used herein. Likewise, "semiconductor substrate" may be used to identify wafers and other structures to be singulated into smaller elements.

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Please replace paragraph **[0029]** with the following:

**[0029]** The saw 10 is capable of lateral multi-indexing of the table 22 having a chuck 500 or blade 18 or, in other words, translatable from side-to-side in drawing FIG. 2 and into and out of the plane of the page in drawing FIG. 1, various nonuniform distances. As noted before, such nonuniform distances may be mere multiples of a unit distance, or may comprise unrelated varying distances, as desired. Accordingly, a substrate 24 having variously sized integrated circuits or other devices or components therein may be sectioned or diced into its non-uniformly sized components by the multi-indexing saw 10. In addition, as previously alluded, the saw 10 may be used to create scribe lines or cuts that do not extend through the substrate 24. The substrate 24 can then subsequently be diced by other methods known in the art or sawed completely through after the blade 18 has been lowered to traverse the substrate to its full depth or thickness.

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Please replace paragraph **[0030]** with the following:

**[0030]** Before proceeding further, it will be understood and appreciated that design and fabrication of a substrate saw for use with the present invention having the previously referenced, multi-indexing capabilities, independent lateral blade translation and independent blade raising or elevation is within the ability of one of ordinary skill in the art, and that likewise, the control of

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such a device to effect the multiple-indexing (whether in units of fixed increments or otherwise), lateral blade translation and blade elevation may be effected by suitable programming of the software-controlled operating system, as known in the art. Accordingly, no further description of hardware components or of a control system to effectuate operation of the apparatus of the invention is necessary.

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Please replace paragraph **[0031]** with the following:

**[0031]** Referring now to drawing FIG. 3, another illustrated embodiment of a substrate saw 30 is shown having two laterally spaced blades 32 and 34 with their centers of rotation "C" in substantial parallel alignment transverse to the planes of the blades. For a rectangular substrate or a conventional substantially circular silicon semiconductor wafer each having a plurality of similarly configured semiconductor devices 42 (not shown) or integrated circuits 42 (not shown) arranged in evenly spaced rows and columns, the blades can be spaced a distance "D" substantially equal to the distance between adjacent areas 44 or streets 44 (not shown) defining the space between each integrated circuit 42. In addition, if the areas 44 of a substrate 40 or streets 44 of wafer 40 are too closely spaced for side-by-side blades 32 and 34 to cut along adjacent streets, the blades 32 and 34 can be spaced a distance "D" substantially equal to the distance between two or more areas 44 or streets 44. For example, a first pass of the blades 32 and 34 could cut along streets 44a and 44c and a second pass along streets 44b and 44d. The blades could then be indexed to cut the next series of areas or streets and the process repeated as desired number of times. If, however, the semiconductor devices 42 of a substrate 40 or integrated circuits 42 of a wafer 52 have various sizes, such as integrated circuits 50 and 51 as illustrated in drawing FIG. 9, at least one blade 34 is laterally translatable relative to the other blade 32 to cut along the areas or streets 44, such as street 56, separating the variously sized integrated circuits 50. The blade 34 may be variously translatable by a stepper motor 36 having a lead screw 38 or by other devices known in the art, such as high precision gearing in combination with an electric motor or hydraulics, or other suitable mechanical drive and control assemblies. For a substrate 40 or wafer 52, the integrated circuits, such as integrated circuits 50 and 51, may

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be diced by setting the blades 32 and 34 to simultaneously cut along areas 58 or 59 (See drawing FIG. 6.) streets 56 and 57, indexing the blades, setting them to a wider lateral spread and cutting along areas 56 or 57 or areas 58 and 59, indexing the blades while monitoring the same lateral spread or separation and cutting along streets 60 and 61, and then narrowing the blade spacing and indexing the blades and cutting along other areas (not shown) and streets 62 and 63. The substrate 40 or wafer 52 could then be rotated 90° and the blade separation and indexing process repeated for areas 58 or 59 or vice versa (See drawing FIG. 6.) and streets 64 and 65, streets 66 and 67, and streets 68 and 69.

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Please replace paragraph **[0032]** with the following:

**[0032]** As illustrated in drawing FIG. 4, a wafer saw 70 according to the present invention is shown having two blades 72 and 74, one of which is independently raisable (as indicated by an arrow) relative to the other. As used herein, the term "raisable" includes vertical translation either up or down. Such a configuration may be beneficial for situations where the distance between adjacent cutting areas of a substrate and/or streets of a wafer is less than the minimum lateral achievable distance between blades 72 and 74, or only a single column of narrow semiconductor devices or semiconductor dice is to be cut, such as at the edge of a substrate or wafer. Thus, when cutting a wafer 80, as better illustrated in drawing FIG. 10 depicting a wafer, the two blades 72 and 74 can make a first pass along streets 82 and 83. One blade 72 can then be raised, the wafer 80 indexed relative to the unraised blade 74 and a second pass performed along street 84 only. Blade 72 can then be lowered and the wafer 80 indexed for cutting along streets 85 and 86. The process can be repeated for streets 87 (single-blade pass), 88, and 89 (double-blade pass). The elevation mechanism 76 for blade 72 may comprise a stepper motor, a precision-geared hydraulic or electric mechanism, a pivotable arm which is electrically, hydraulically or pneumatically powered, or other means well-known in the art.

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Please replace paragraph **[0033]** with the following:

**[0033]** Finally, it may be desirable to combine the lateral translation feature of the embodiment of the substrate saw 30 illustrated in drawing FIG. 3 with the independent blade raising feature of the wafer saw 70 of drawing FIG. 6. Such a wafer saw could use a single blade to cut along areas or streets that are too closely spaced for dual-blade cutting or in other suitable situations, and use both blades to cut along variously spaced areas or streets where the lateral distance between adjacent cutting areas or streets is sufficient for both blades to be engaged.

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Please replace paragraph **[0036]** with the following:

**[0036]** As shown in drawing FIG. 12, a portion of a substrate 200 is depicted with three adjacent columns of varying-width segments, the three widths of segments illustrating batteries 202, chips 204 and antennas 206 of a semiconductor device, such as an RFID device. With all of the RFID components formed on a single substrate 200, an RFID module may be assembled by a single pick-and-place apparatus at a single work station. Thus, complete modules may be assembled without transfer of partially assembled modules from one station to the next to add components. Of course, this approach may be employed to any module assembly wherein all of the components are capable of being fabricated on a single semiconductor substrate. Fabrication of different components by semiconductor device fabrication techniques known in the art is within the ability of those of ordinary skill in the art, and therefore no detailed explanation of the fabrication process leading to the presence of different components on a common wafer or other substrate is necessary. Masking of semiconductor device elements not involved in a particular process step is widely practiced, and so similar isolation of entire components is also easily effected to protect the elements of a component until the next process step with which it is involved.

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Please replace paragraph **[0037]** with the following:

**[0037]** Further, the saw used with the present invention has particular applicability to the fabrication of custom or nonstandard integrated circuits or other components, wherein a capability

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for rapid and easy die size and shape adjustment on a substrate-by-substrate or wafer-by-wafer basis is highly beneficial and cost-effective. In the present saw it may be desirable to have at least one blade of the independently laterally translatable blade configuration be independently raisable relative to the other blade or blades, or a single blade may be both translatable and raisable relative to one or more other blades and to the target substrate or wafer. In addition, while for purposes of simplicity, some of the preferred embodiments of the substrate saw are illustrated as having two blades, however, the saw may have more or less than two blades.

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Please replace paragraph **[0038]** with the following:

**[0038]** Referring to drawing FIG. 5, a first side 300 of a substrate 40 is illustrated having a plurality of semiconductor devices 42 located thereon. Each semiconductor device 42 having been previously encapsulated in a suitable molding process. The substrate 40 may be of any suitable material, such as described herein.

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Please replace paragraph **[0040]** with the following:

**[0040]** Referring to drawing FIG. 7, illustrated in a top view is a dicing chuck 500 suitable for use with the table 22 of the substrate saw 10 and the substrate 40 illustrated in drawing FIGS. 5 and 6. The chuck 500 comprises a chuck table 502 having a shaft 528 (Fig. 8) attached thereto for mounting on the table 22 using suitable apparatus, a plurality of cutting pedestals 504 having the desired spacing to mate with the semiconductor devices 42 of substrate 40 and connectors 306 of another side 302 of substrate 40, a pair of clamps 506 mounted on clamp pedestals 508 (see drawing FIG. 8), and one or more alignment pins 510, if desired, for aligning the substrate 40 on the chuck 500. Each cutting pedestal 504 includes a portion 512 having an aperture 514 therein for mating with the portion of the semiconductor device 42 on another side 302 thereof and portions 516 having a plurality of recessed areas 518 therein for mating with the connectors 306 in areas 308 (see FIG. 6) of another side 302 of substrate 40. The aperture 514 in the cutting pedestal 504 may be connected to a source of vacuum (not shown) to help retain the semiconductor devices 42 on the cutting pedestal 504. The shape, size

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and spacing of the recessed areas 518 on each cutting pedestal 504 will vary with the type, size, and spacing of the connectors 306 of another side 302 of substrate 40. The clamps 506 mounted on clamp pedestals 508 may be secured thereto by any suitable type of retaining apparatus, such as a threaded member 520. The chuck 500 may be fabricated from any suitable material, such as metal commonly used for the dicing of substrates having semiconductor devices thereon.

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Please replace paragraph **[0041]** with the following:

**[0041]** Referring to drawing FIG. 8, the chuck 500 illustrated in a side view. As shown, the apertures 514 in each cutting pedestal 504 has an aperture 522 connected to aperture 524 which, in turn, is connected to aperture 526 in the chuck shaft 528 to supply vacuum from a source of vacuum to each cutting pedestal 504. The shape, size, configuration, and layout of the apertures 522, 524, and 526 may be any suitable desired configuration to supply vacuum to each cutting pedestal 504. The alignment pins 510 mate with alignment apertures 43 in the substrate 40 (See drawing FIGS. 5 and 6.). The alignment pins 510 may be any desired configuration, size, and shape to mate with any alignment aperture in substrate 40. The threaded member 520 may be any suitable type to retain the substrate clamps 506 on the clamp pedestals 508. The substrate clamps 506 may be of any suitable shape, size, and configuration to mate with portions of the substrate 40 to retain portions thereof on the cutting pedestals 504 and, if desired, on clamp pedestal 508.

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